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User's Manual for Agricultural Runoff Management (ARM) Model

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terminates the input of each separate nutrient application. For multiple applications, the sequence is repeated with the character string APPLICATION and the Julian day of application. Applications must be sequential with the first one applied in the'year appearing first in the input sequence. The application section is followed by the soil namelist statements (LZTP, RETP, DPTH) shown in Table 5.2. This completes the nutrient parameter input sequence.

5.3 PARAMETER EVALUATION GUIDELINES

Guidelines for evaluating the ARM Model parameters relating to hydrology, snowmelt, sediment, pesticide, and nutrient simulation are provided below. The simulation control parameters are described by their definition in Table 5.1 and discussed in Section 5.1.1. Also, guidelines are provided below for obtaining initial values of the calibration parameters. However, precise evaluation of these parameters can only be obtained through calibration procedures discussed in Section 6.

5.3.1 Hydrology Parameters

A — A is the fraction representing the impervious area in the watershed. Usually A will be negligible for agricultural watersheds, except in cases of extensive rock outcrops along channel reaches.

HYMIN — HYMIN is a control parameter representing the minimum flow above which storm output is printed, and should be chosen to include the significant portion of the storm hydrograph and pollutant graph. Investigation of recorded storm hydrographs and pollutant graphs will indicate an appropriate value of HYMIN. Also, a large value for HYMIN will prevent printing of storm output during calibration runs.

EPXM — This interception storage parameter is a function of cover density, and represents the maximum interception attained during the year. The following values are expected:

grassland	0.10 in.	2.5 mm
cropland (maximum canopy)	0.10-0.25 in.	2.5-6.5 mm
forest cover (light)	0.15 in.	3.5 mn
forest cover (heavy)	0.20 in.	5.0 mm

The effective interception on any day is calculated in the model as a function of crop canopy. It is equal to EPXM times the fraction of maximum canopy on that day:

$$\text{Interception (Day T)} = \text{EPXM} * \frac{\text{Canopy (Day T)}}{\text{Maximum Canopy}}$$

UZSN — The naninal storage in the upper zone is generally related to LZSN and watershed topography. However,

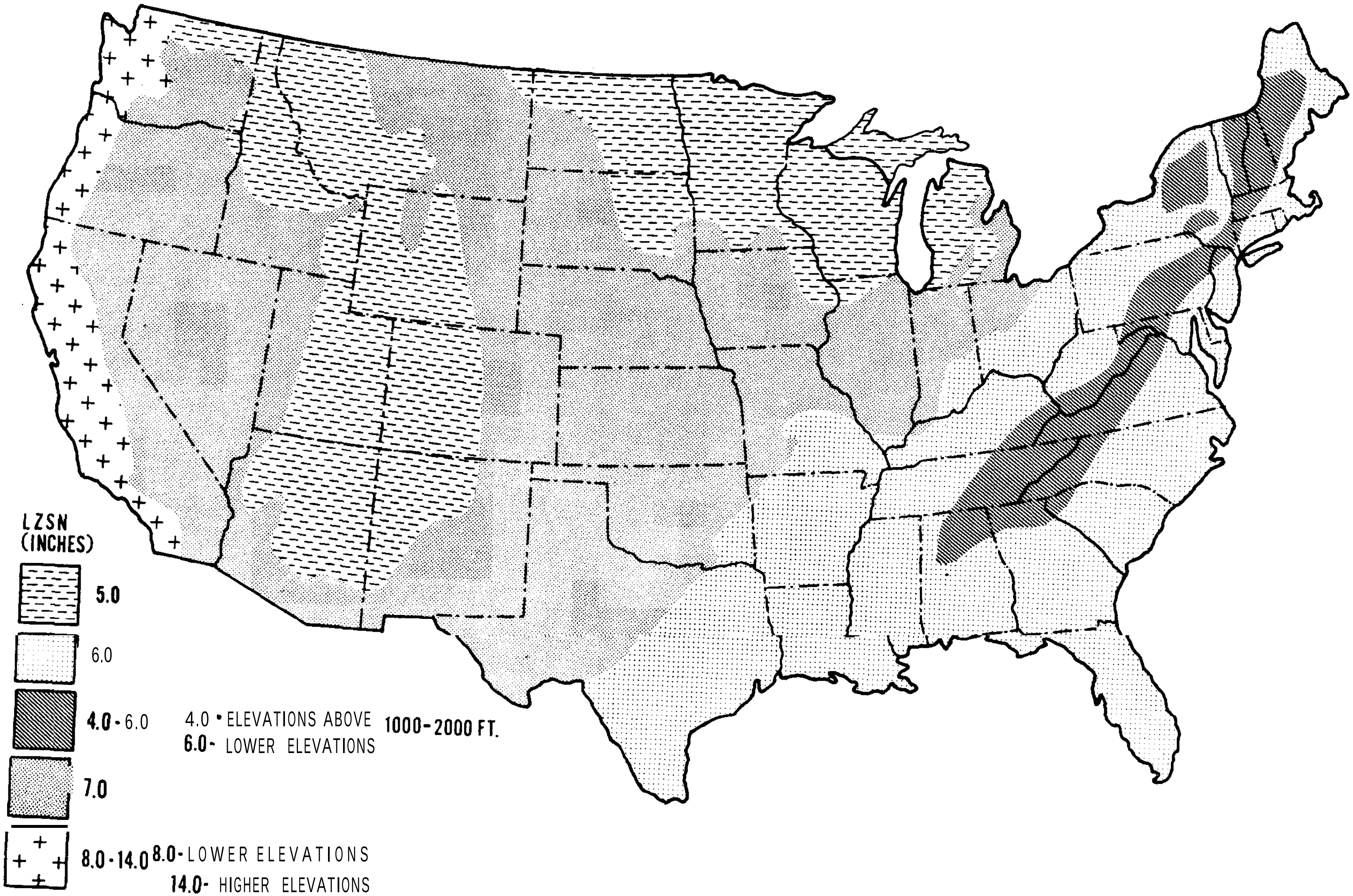

Figure 5.1 Nominal lower zone soil moisture (LZSN) parameter map

TABLE 5.4 WATERSHEDS WITH CALIBRATED LANDS PARAMETERS

Watershed Information					LANDS Parameters					
No.	General Location	Name	Area (sq mi)	Type	Model	UZSN	LZSN	INFIL	INTER	Comments
1	Seattle, Washington	Lower Green R			HSP	3.0	12.0	0.06	10.0	
		Middle Green R			HSP	1.15	9.5	0.10	3.0	
		Upper Green R			HSP	0.9	14.0	0.05	11.5	
		Lake Washington			HSP	0.5	8.0	0.05	10.0	
2	Spokane, WA	Little Spokane R		plains, rural	HSP	0.56	7.0	0.20	15	
3	Aschoft, Oregon	Bull Run	107	rural, steep forest	HSP	0.75	14.0	0.08	3.5	
4	Whiteson, Oregon	South Yamhill R	502		NWS	1.20	5.3	0.24	0.5	POWER=0.37
5	Central Sierra Snowlab, CA	Upper Castle Creek	3.96	rural, rocky forest	NWS	0.70	9.0	0.08	0.67	POWER=1.5
6	between Chico and Flemming, CA	N Fork Feather R	300	rural, steep forest	HSP	0.8	12.0	0.12	2.5	
7	Cloverdale, CA	Dry Creek	878	rural, moderate slope, chaparral	SWM V	0.8	15.0	0.03	1.8	
	Napa, CA	Dry Creek	14.4	rural, moderate slope, chaparral	HSP	0.8	12.0	0.025	2.5	
8	Burlingame, CA	Colma Creek	10.8	urban, moderate slopes	HSP	0.25	12.0	0.07	2.0	
9	Santa Cruz, CA	Branciforte Creek	17.3	rural	HSP	1.0	16.0	0.04	2.5	
10	San Mateo Co, CA	Denniston Creek	3.6	rural, steep chaparral	SWM IV	0.95	12.7	1.35	2.0	
11	Santa Ynez, CA	Sisquoc River	281	rural, steep light chaparral	HSP	0.7	8.5	0.18	1.5	
12	Santa Maria, CA	Santa Maria River	2.38	urban, flat slopes	HSP	0.3	5.0	0.02	1.4	
13	Goleta, CA	San Jose Creek	5.5	rural, steep	HSP	0.5	10.0	0.03	3.5	
14	Santa Ynez, CA	Santa Ynez River	895	rural, steep	HSP	0.74	8.3	0.035	1.5	
15	Los Angeles, CA	Echo Park	0.4	urban, steep residential	HSP	0.04	5.0	0.03	0	
16	Pasadena, CA	Arroyo Seco	16	urban, steep	HSP	0.20	7.0	0.05	1.2	
17	Upper Columbia Snowlab, MT	Skyland Creek	8.1	rural, steep	NWS	1.83	10.7	0.071	5.6	POWER=0.83
18	Denver, CO	South Platte R		rural, moderate slope, grasses	HSP	0.1	0.7	0.03	1.0	
19	30 mi. south of Denver, CO	Cherry Creek	69	rural, moderate	HSP	0.8	7.0	0.005	3.0	

(continued)

TABLE 5.4 (continued)

Watershed Information					LAND Parameters					
No.	General Location	Name	Area (sq mi)	Type	Model	UZSN	LZSN	INFIL	INTER	Comments
20	Sperry, OK	Bird Creek	905	slope, grassland	NWS	1.38	10.0	0.048	0.67	POWER=0.78
21	Austin, TX	Waller Creek	5.5	urban, moderate	HSP	1.0	8.0	0.04	1.25	
22	Bryon, TX	Burton Creek	1.3	urban, flat	HSP	0.3	5.0	0.02	1.5	
23	Lannesboro, MN	Root River	625		NWS	0.2	5.0	0.08	0.5	POWER=2.0
24	Rock Rapids, IA	Rock River	788		NWS	0.75	4.0	0.02	1.4	POWER=2.5
25	Iowa City, IA	Rapid Creek	25.3		HSP	0.5	7.0	0.035	3.5	
26	St. James, MO	Bourbeuse River	21.3		HSP	0.75	5.0	0.02.	1.0	
27	Steelville, MO	Meramec River	781		NWS	1.2	12.7	0.043	1.05	POWER=1.56
28										
29	Nettleton, ID	Town Creek	617		NWS	0.44	7.35	0.066	0.89	POWER=2.6
30	Collins, MI	Leaf River	752		NWS	0.05	7.5	0.33	0.37	POWER=2.85
31	Chicago, IL	North Branch, Chicago River	100	urban, flat,	HSP	1.4	7.5	0.18	3.5	
32	Northbrook, IL	W Fork N Branch Chicago River	11.5	rural	HSP	1.40	7.5	0.18	3.0	
33	Champaign/Urbana, IL	Boneyard Creek	3.6	urban, flat slope	HSP	0.80	7.5	0.05	2.0	
34	Selkirk, MI	S Branch Shepards Creek	1.2		HSP	1.0	5.0	0.04	1.0	
35	Springfield, OH	Mad River	490		NWS	0.41	4.1	0.125	0.83	POWER=0.40
36	Green Lick Reservoir, PA	Green Lick Run	3.1		HSP	1.0	8.0	0.007	1.0	
37	Frederic, MD	Monocacy River	817		NWS	1.2	1.75	0.058	1.0	POWER=0.30
38	E of Washington D.C. in MD	W Branch of Patuxent River	30.2	rural, flat	HSP	1.2	7.0	0.02	2.0	
39	Rosman, NC	French Broad R	67.9	rural, limestone Forest	NWS	0.01	5.38	0.8	0.25	POWER=0.36
40	Swannanoa, NC	Beetree Creek	5.5	rural	HSP	0.30	3.0	0.10	30	
41	Blairsville, GA	Nottely River	74.8	rural, forest mountains	NWS	0.02	3.4	0.45	2.5	POWER=2.0
42	Fayetteville, GA	Camp Creek	17.2	urban, hilly Forests	NWS	0.5	5.0	0.16	0.75	POWER=2.0
43	Alma, GA	Hurricane Creek	150	rural, forested	NWS	0.2	2.0	0.13	2.6	POWER=2.0
44	Danville, VT	Sleepers River	3.2	rural	NWS	0.25	4.55	0.40	0.25	POWER=3.0
45	Passumpic, VT	Passumpsic River	436	rural	NWS	0.15	5.0	0.33	0.9	POWER=3.0

(continued)

TABLE 5.4 (continued)

Watershed Information					LAND Parameters					
No.	General Location	Name	Area sq mi)	Type	Model	UZSN	LZSN	NFIL	INTER	Comments
46	West Hartford, VT	White River	690	rural	NWS	3.25	5.0	0.15	1.3	POWER=0.95
47	Grafton, VT	Saxton River	72.2		SWM v	0.8	8.0	0.05	2.0	
48	Bath, NH	Ammonoosuc River	395	rural	NWS	0.3	5.0	0.12	0.65	POWER=1.50
50	Plymouth, NH	Pemigewasset River	622	rural	NWS	0.25	5.0	0.22	0.53	POWER=2.08
51	Knightsville Cam, MA	Sykes Brook	1.6		HSP	1.2	8.0	0.03	1.0	
others										
52	Fairbanks, AK	Chena River	1980		NWS	0.05	5.0	0.08	0.25	POWER=1.0
53	Seattle, WA	Issaquah Creek	55	rural, steep heavy forest	HSP	1.12	14.0	0.03	7.0	
54	Spokane, WA	Hangman Creek	54	agriculture	HSP	0.50	7.0	0.02	3.5	
55	Santa Cruz, CA	Neat-y's Lagoon	1.0	urban, steep	HSP	0.80	11.0	0.04	2.5	
56	Ingham, Co. MI	Deer Creek	16.3	rural, flat agriculture	HSP	1.5	5.n	0.05	2.0	
57	Athens, GA	Southern Piedmont	0.01	small plot watersheds	PTR	0.05	18.0	0.5	0.7	
				RANGES		1.01-3.0	.75-18	.005-1.35	11.5-25	

a. HSP Hydrocomp Simulation Program
SWM IV Stanford Watershed Model IV
SWM v Stanford Watershed Model V
NWS National Weather Service Model
PTE Pesticide Transport and Runoff Model

b. HSP and the SWM Models use a value of 2.0 in the ir.filtration function while the NWS Model allows the user to specify this value with the POWER parameter. The values of POWER are indicated in the comments column.

depending on the cohesiveness and permeability of the soil. Initial values for INFIL can be obtained by reference to the hydrologic soil groups of the Soil Conservation Service (1974) in the following manner:

SCS Hydrologic Soil Group	INFIL Estimate (in./hr)	(mm/hr)	Runoff Potential
A	0.4-1.0	10.0-25.0	low
B	0.1-0.4	2.5-10.0	moderate
C	0.05-0.1	1.25-2.5	moderate to high
D	0.01-0.05	.25-1.25	high

The SCS has specified the hydrologic soil group for various soil classifications across the country (1974). As for LZSN, the values of INFIL obtained above should be used with caution and only as initial values to be checked by calibration.

INTER — This parameter refers to the interflow component of runoff and generally alters runoff timing. It is closely related to INFIL and LZSN and values generally range from 0.5 to 5.0. Figure 5.3 provides an approximate mapping of the INTER parameter for the United States. This map was obtained as described for the LZSN parameter. In addition, INTER values in Table 5.4 provide an indication of representative values. This information should be used only to obtain initial values that need to be checked by calibration.

L is the length of overland flow obtained from topographic maps and approximates the length of travel to a stream channel. Its value can be approximated by dividing the watershed area by twice the length of the drainage path or channel. Values usually range from 100 ft (30 meters) to 300 ft (90 meters) since overland flow rapidly forms into drainage ditches.

SS — SS is the average overland flow slope obtained from topographic maps. The average slope can be estimated by superimposing a grid pattern on the watershed, estimating the land slope at each point of the grid, and obtaining the average of all values measured.

NN — Manning's n for overland flow will vary considerably from published channel values because of the extremely small depths of overland flow. Approximate values are:

smooth, packed surface	0.05
normal roads and parking lots	0.10
disturbed land surfaces	0.15

to streamflow. It is usually set to 0.0 for initial calibration runs. The factor (1.0-K24L) specifies the fraction of the total groundwater component added to SW, while the outflow from active groundwater is determined by the recession rate, KK24. UZS and LZS are generally specified relateive to their nominal storages, UZSN and LZSN. If simulation begins in a dry period, UZS and LZS should be less than their nominal values; whereas values greater than nominal should be employed if simulation begins in a wet period of the year. UZS, LZS, and SGW should be reset after a few calibration runs according to the guidelines provided in Section 6.

5.3.2 Snow Parameters

RADCON, CCFAC These parameters adjust the theoretical melt equations for solar radiation and condensation/convection melt to actual field conditions. Values near 1.0 are to be expected although past experience indicates a range of 0.5 to 2.0. RADCON is sensitive to watershed slopes and exposure, while CCFAC is a function of climatic conditions.

SCF — The snow correction factor is used to compensate for catch deficiency in rain gages when precipitation occurs as snow. Precipitation times the value of (SCF-1.0) is the added catch. Values are generally greater than 1.0 and usually are in the range of 1.0 to 1.5.

ELDIF — This parameter is the elevation difference from the temperature station to the mean elevation in the watershed in thousands of feet (or kilometers). It is used to correct the observed air temperatures for the watershed using a lapse rate of 3^{o}F per 1,000 ft elevation change (5.5% per 1,000 m).

IDNS — This parameter is the density of new snow at 0^{o} F. The expected values are from 0.10 to 0.20 with 0.15 a common value. The relationship for the variation in snow density with temperature is described by Donigian and Crawford (1976a).

This parameter is the fraction of the watershed that has complete forest cover. Area1 photographs are the best basis for estimates.

DGM — DGM is the daily groundmelt. Values of 0.01 in/day (0.25 mm/day) are usual. Areas with deep frost penetration may have little groundmelt with DGM values approaching 0.0.

WC — This parameter is the maximum water content of the snowpack by weight. Experimental values range from 0.01 to 0.05 with 0.03 a cannon value.

MPACK — MPACK is the estimated water equivalent of the snowpack for canplete area1 coverage in a watershed. Values of 1.0 to 6.0 in. (25 to 150 mm) are generally employed. MPACK is a function of topography and climatic conditions. Mountainous watersheds will generally have MPACK values near the high end of the range.

EVAPSN — EVAPSN adjusts the amounts of snow evaporation given by an analytic equation. Values near 0.1 are expected.

MELEV — The mean elevation of the watershed in feet (meters).

TSNOW — Wet bulb air temperature below which snow is assumed to occur. Values of 31° to 33° F (-0.6 to + 0.6° C) are often used. Comparing the recorded form of precipitation and the simulated form for a number of years will indicate needed modifications to TSNOW.

PETMIN, PETMAX — These parameters allow a reduction in potential evapotranspiration for air temperatures near or below 32° F (0° C). PETMIN specifies the air temperature below which potential evapotranspiration is zero. For air temperature between PETMIN and PETMAX, potential evapotranspiration is reduced by 50 percent while no reduction is performed for temperatures above PETMAX. Values of 35° F (1.7° C) and 40° F (4.4° C) have been used for PETMIN and PETMAX, respectively.

WMUL, RMUL — These parameters are multipliers used to adjust input wind movement and solar radiation, respectively, for expected conditions on the watershed. Values of 1.0 are used if the input meteorologic data are observed on or near the watershed to be simulated.

KUGI — KUGI is an integer index to forest density and undergrowth for the reduction of wind in forested areas. Values range from 0 to 10; for KUGI = 0, wind in the forested area is 35 percent of the input wind value, and for KUGI = 10 the corresponding value is 5 percent. For medium undergrowth and forest density, a KUGI value of 5 is generally used.

5.3.3 Sediment Parameters

JRER — JRER is the exponent in the soil splash equation of the sediment algorithm; it approximates the relationship between rainfall intensity and incident energy to the land surface for the production of soil fines. Wischmeier and Smith (1958) have proposed the following relationship for the kinetic energy produced by natural rainfall;

$$Y = 916 + 331 \log X$$